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ABSTRACT

This course of instruction in advanced chemistry is intended for the student ready for first-year college chemistry. Presented is an in-depth review with theory and mathematics being stressed in the study of concepts involving atomic structure, bonding, states of matter, molar relationships in equations, and properties of solutions. It is suggested that the course play a major role in preparing the student for the Advanced Placement Test in chemistry. Guidelines for enrollment into the course are included. Fourteen performance objectives are listed and a detailed course outline is presented. Ninety-five experiments, drawn from several different curricula, are presented as part of the student performance activities. Additional related learning experiences included in the course description are suggested projects, reports, field trips and related problems. A reference list for films, film loops, and film strips is presented as well as references for books and articles. A master sheet coordinating the entire curriculum is included. (Author/EB)

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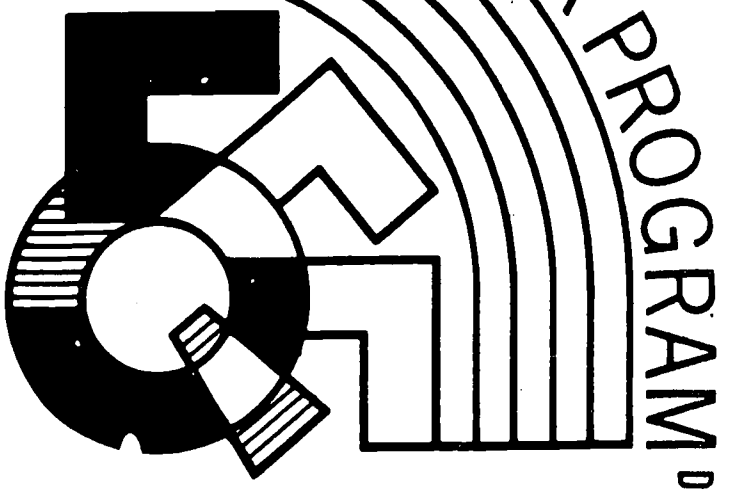

ATOMS, MOLECULES, AND KINETIC THEORY

5317.63

SCIENCE

(Experimental)

5317 120

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION • 1971

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(Experimental)

Written by Jacquelin F. Buffaloe
for the
DIVISION OF INSTRUCTION
Dade County Public Schools
Miami, Florida
1972

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ATOMS, MOLECULES. AND KINETIC THEORY

COURSE DESCRIPTION

Atoms, Molecules, and Kinetic Theory is intended for the student ready for first year college chemistry. It is a review in depth with theory and mathematics being stressed in the presentation and study of concepts involving atomic structure, bonding, states of matter, molar relationships in equations, and properties of solutions. This course should play a major role in preparing the student for the Advanced Placement Test in chemistry. Guidelines for activities and depth for Advanced Placement Program courses are in the current edition of Advanced Placement Course Descriptions which is available in each high school.

ENROLLMENT GUIDELINES

Students should have successfully completed Scientific Mathematics, Introduction to Chemistry, Reactions of Atoms and Molecules, Energy of Atoms and Molecules, and The Dynamic Nature of Atoms and Molecules. The student should be advanced in mathematics. Readiness proven by a test is acceptable and suggested.

STATE ADOPTED TEXTS

1. Brown, Theodore L. General Chemistry. Columbus, Ohio: Charles E. Merrill Publishing Company, 1968.

2. Mahan, Bruce H. College Chemistry. Reading, Mass.: Addison-Wesley Publishing Company, 1966.

PERFORMANCE OBJECTIVES

1. The student will describe the "plum pudding", Bohr, and quantum mechanical models of the atom and will include the failures of the Bohr Model.

2. Given a list of names of people whose work has contributed to the development of atomic models, the student will state the discovery made by those scientists.

3. Given a specific electron in any of the first 4 major energy levels, the student will write the values for the quantum numbers n, l, m, and s.

4. Given the mass number for 2 or more possible isotopes of the same element and the fact that they may form both +1 and +2 ions, the student will explain the method by which the mass spectroscope will separate them.

5. Given the valence shell electron configuration for any element and a periodic table, the student will select the correct chemical symbol.

6. Given the periodic table, the student will explain the relationship between the variation in structure and each of the following trends in both families and periods: (1) size, (2) ionization energy, (3) electronegativity, (4) oxidation states, (5) metallic properties (conductivity, ion formation, and acidity of oxides and hydrides), (6) types of elemental solid formed, and (7) melting and boiling points.

7. Given the periodic table or a table of electronegativities and a molecular formula, the student will predict:

   (1) the type of solid the compound would form,
   (2) type of bonds involved in and between molecules,
   (3) state at room temperature,
   (4) shape of the molecule,
   (5) crystalline shape,
   (6) relative solubility in water,
   (7) if the molecule is a resonance structure, and
   (8) the type of hybrid bonds, if any exist.

8. Given the volume, conditions under which a gas was collected over water, and the vapor pressure at that temperature, the student will calculate the dry volume at STP.

PERFORMANCE OBJECTIVES (Continued)

9. Given a flask containing a mixture of two known gases, the total pressure, partial pressure and weight of one of the gases, and the temperature which is constant, the student will calculate the volume of the flask, weight of the second gas, and mole fraction of each gas present.

10. Given the data which would be collected in each procedure listed, the student will calculate the molecular weight of a volatile substance using the (1) Victor Meyer Method, (2) Dumas Method, and (3) Graham Law of Diffusion Method.

11. Given the weight of a solute, weight of water, and the freezing or boiling point deviation, the student will determine the molecular weight of a nonvolatile, nonelectrolytic solute.

12. Given the formula of the solute and the concentration of the solution to be prepared (molarity, molality, percent by weight or volume, or normality), the student will do the necessary calculations to prepare the solution from

    (1) a pure solid or liquid and water,
    (2) two or more solutions of known concentrations, volume, and density, and
    (3) a concentrated solution of known specific gravity and and percent assay and water.

13. The student will explain the effect of the following factors on the solubility of a pure chemical.

    (1) bonding within and between particles
    (2) polarity of the solvent and solute
    (3) pressure
    (4) temperature

14. Given an equation and the specific information listed in each item below, the student will solve the following types of problems:

    (1) given the weight of one chemical involved, calculate the weight of a second chemical used or produced.

    (2) given a gas volume and the conditions under which it was measured, calculate the weight of a second chemical.

PERFORMANCE OBJECTIVES (Continued)

(3) given the gas volume of one chemical and the conditions under which it was measured, calculate the gas volume of a second chemical under different conditions.

(4) given the concentration and volume of a solution of one chemical used, calculate the weight of a second chemical.

(5) given the concentration and volume of a solution of one chemical and either the concentration or volume of a second chemical, calculate either the concentration or volume of the second chemical.

COURSE OUTLINE

I. Atomic Structure

A. Development of the three atomic models

1. Plum Pudding

a. Discovery of electron - work of Thomson and Millikan
b. Disadvantages of model

2. Bohr model

a. Work of Rutherford, Bohr, Summerfeld, Balmer, Paschen, and Einstein
b. Advantages and disadvantages in using the planetary or Bohr model of the atom

3. Quantum mechanical model of the atom

a. Work of Compton, DeBroglie, Heisenberg, Schroedinger, Davison and Germer, and Pauli
b. s,p,d,f electron configurations
c. Quantum numbers

B. Isotopes and mass spectroscopy

C. Feriodic law

1. Arrangement of elements on periodic table as related to their electron configurations - Exceptions in predicted structure (e.g. Cr and Cu)

COURSE OUTLINE (Continued)

2. Trends in families and periods or rows based on variation in structure

   a. Size
   b. Ionization energy
   c. Electronegativity
   d. Metallic properties (conductivity, ion formation, and acidity of oxides and hydrides)
   e. Melting and boiling points
   f. Types of elemental solid formed
   g. Oxidation states

II. Chemical Bonds

A. Bond types

1. Covalent

2. Electrovalent

3. Polar - ionic character

4. Hydrogen "bond"

5. van der Waals forces

B. Chemical and physical properties and their relation to bond type

C. Resonance structures

D. Hybridization of orbitals (s,p and s,p,d)

E. Geometry of molecules

1. Isomerization

2. Polarity

III. States of Matter - Kinetic Molecular Theory

A. Properties of gases

1. Gas laws, including application of Charles', Boyle's, Gay-Lussac's, Graham's and Dalton's laws and the general equation of state

2. Deviation from the gas laws

COURSE OUTLINE (Continued)

B. Properties of liquids

C. Properties of solids

1. Five types of solids based on bonding

2. Crystals - types, method of formation (energy) and water of hydration

IV. Solutions

A. Physical properties

1. Concentration - molarity, molality, percent by weight and volume, normality

2. Boiling and freezing points (vapor pressure)

3. Difference in a solution, colloid, gel and aerosol

4. Separation of components in a solution by the use of physical properties

B. Dissolving process

1. Mechanisms by which chemicals dissolve

2. Factors which affect solubility

V. Mole Concept as Applied to Stoichiometric Calculations

A. Weight - weight problems

B. Weight - gas volume problems

C. Gas volume - gas volume problems

D. Weight - liquid volume problems

E. Liquid volume - liquid volume problems

EXPERIMENTS

Barrett, Richard L. and Price, Jack. Chemistry - A Modern Course Laboratory Manual. Columbus, Ohio: Charles E. Merrill Books, Inc., 1965.

1. Boyle's Law (exp. 18, p. 35)
2. Crystallization (exp. 26, p. 53)
3. Determination of Molecular Weight: Vapor Density (exp. 21, p. 43)
4. Family Characteristics (exp. 13, p. 25)
5. Factors Affecting Solution (exp. 25, p. 51)
6. Graham's Law: Rate of Diffusion (exp. 15, p. 29)
7. Molar Volume of a Gas (exp. 20, p. 39)
8. Molecular Models (exp. 14, p. 27)
9. Partially Miscible Liquids (exp. 27, p. 55)
10. Percent of Water in a Hydrate (exp. 17, p. 33)
11. The Spectra of Elements (exp. 12, p. 23)
12. Weight of Reacting Substances (exp. 24, p. 49)

Castka, Joseph F.; Metcalfe, H. Clark; and Williams, John E. Exercises and Experiments in Chemistry. New York: Holt, Rinehart and Winston, 1966.

13. Chemical Properties of Water (exp. 17, p. 161)
14. Colloidal Suspensions (exp. 32, p. 209)
15. Covalent Molecules (exp. 6, p. 135)
16. Conductivity of Solutions (exp. 24, p. 181)
17. Flame Tests (exp. 48, p. 261)
18. Mass Relations in Chemical Change (exp. 11, p. 147)
19. Molar Volume of a Gas (exp. 15, p. 157)
20. Molecular Weight of a Gas (exp. 16, p. 159)
21. Percent of Water in a Hydrate (exp. 19, p. 165)
22. Solid State, Crystals and Crystallization (exp. 21, p. 171)
23. Solubility Curve (exp. 23, p. 179)
24. Solubility, Rate of Solution, Heat of Solution (exp. 22, p. 175)
25. Solution and Molecular Polarity (exp. 20, p. 167)
26. Water of Hydration (exp. 18, p. 163)

Chemistry 2: Advanced Placement Course Outline and Manual of Laboratory Activities. Curriculum Bulletin 8-D. Miami, Florida: Dade County Public Schools, 1966.

27. Boyle's Law (exp. 18, p.105)
28. Charles' Law (exp. 19, p. 107)
29. Colloids (exp. 23, p. 119)
30. Crystals and Water of Hydration (exp. 25, p. 126)

EXPERIMENTS (Continued)

31. Distillation (exp. 28, p. 136)
32. Equivalent Weight of Magnesium (exp. 3, p. 56)
33. Hydrogen Sulfide and Hydrosulfuric Acid (exp. 8, p. 74)
34. Molecular Weight of a Gas (exp. 20, p. 109)
35. Oxides of Sulfur (exp. 7, p. 70)
36. Relative Activity of Metals (exp. 29, p. 142)
37. Relative Strengths of Acids and Bases (exp. 13, p. 91)
38. Solubility (exp. 21, p. 113)

Davis, Joseph E.; MacNab, W. Keith; Haenisch, Edward L.; McClellan, A. L.; and O'Connor, Paul R. Laboratory Manual for Chemistry Experiments and Principles. Lexington, Mass.: Raytheon Education Co., 1968.

39. Formula of a Hydrate (exp. 9, p. 26)
40. Packing of Atoms in Crystals (exp. 38, p. 97)
41. Reaction of Magnesium and Hydrochloric Acid (exp. 11, p. 29)
42. Temperature - Volume Relation (exp. 10, p. 27)
43. Types of Solutions (exp. 18, p. 52)

Ferguson, Harold; Schmuckler, Joseph; and Siegelman, Irwin. Investigating Matter, Energy and Change. Morristown, New Jersey: Silver Burdett Company, 1966.

44. Density of a Gas (exp. 7, p. 49)
45. Mole and the Molar Volume (exp. 8, p. 53)
46. Mole Ratios and Chemical Reactions: I (exp. 10, p.63)
47. Mole Ratios and Chemical Reactions: II (exp. 13, p. 97)
48. Mole Ratios and Chemical Reactions: III (exp. 26, p. 193)
49. Solutions and Solubility (exp. 20, p. 153)
50. Solution Species and Precipitation (exp. 21, p. 157).

Geffner, Saul and Lauren, Paul. Experimental Chemistry and Workbook. New York: Amsco Publications, 1968.

51. Boyle's Law (exp. 12, p. 47)
52. Charles' Law (exp. 13, p. 51)
53. Constructing Molecular Models (exp. 36, p. 143)
54. Crystal Models (exp. 35, p. 139)
55. Determination of Atomic Weight Using Specific Heat Data (exp. 17, p. 71)
56. Determination of Percent of Water in a Hydrate (exp. 10, p. 41)
57. Electrical Conductivity of Solutions of Compounds (exp. 11, p. 43)
58. Solutions (exp. 8, p. 37)
59. Stoichiometry and Chemical Change (exp. 15, p. 59)

EXPERIM (Continued)

Greenstone, Arthur W. Concepts in Chemistry Laboratory Manual. New York: Harcourt, Brace, and World, 1966.

60. Basic Crystal Structure (exp. 12, p. 50)
61. Boyle's Law (exp. 14, p. 57)
62. Charles' Law (exp. 15, p. 60)
63. Colloids (exp. 19, p. 70)
64. Conductivity of Chemical Compounds (exp. 28, p. 90)
65. Crystals and Water of Hydration (exp. 18, p. 67)
66. Determination of the Molecular Weight of a Gas (exp. 9, p. 41)
67. Determination of the Gram Equivalent Weight (exp. 11, p. 46)
68. Factors Affecting Solutions (exp. 17, p. 65)
69. Ionic Crystals (exp. 13, p. 53)
70. Molecular Polarity (exp. 29, p. 92)
71. Molecular Weight by Vapor Density Method (exp. 10, p. 44)
72. Solutions and Suspensions (exp. 16, p. 62)

Pimentel, George C. ed. Chemistry: An Experimental Science Laboratory Manual. San Francisco: W. H. Freeman and Company, 1963.

73. A Quantitative Investigation of a Reaction of a Metal with Hydrochloric Acid (exp. 9, p. 26)
74. Mass Relationships Accompanying Chemical Change (exp. 8, p. 22)
75. Packing of Atoms or Ions in Crystals (exp. 27, p. 72)

Smith, William T., Jr. and Wood, Jesse H. Laboratory Manual for College Chemistry. New York: Marper and Row, Publishers, 1966.

76. Charles' Law (exp. 12, p. 51)
77. Colloids (exp. 22, p. 93)
78. Combining Weight of a Metal (exp. 29, p. 123)
79. Formula of a Hydrate (exp. 18, p. 77)
80. Graham's Law of Diffusion (exp. 14, p. 61)
81. Molar Gas Volume (exp. 16, p. 69)
82. Molar Heat Capacity of a Solid; Law of Dulong and Petit (exp. 28, p. 119)
83. Molecular Weight of Carbon Dioxide (exp. 13, p. 55)
84. Periodic Law (exp. 4, p. 21)
85. Solutions; Colligative Properties: I (exp. 19, p. 81)
86. Solutions; Colligative Properties: II (exp. 20, p. 85)

EXPERIMENTS (Continued)

Weaver, Albert C. Scientific Experiments in Chemistry. New York: Holt, Rinehart, and Winston, Inc., 1966.

87. Chemical Properties of Metals (exp. 47, p. 90)
88. Chemical Properties of Nonmetals (exp. 53, p. 106)
89. Conductivity (exp. 26, p. 49)
90. Diffusion (exp. 13, p. 24)
91. Distillation of Liquids (exp. 18, p. 33)
92. Effect of Ion Size on Mutual Solubility (exp. 7, p. 14)
93. Finding Molecular Weights (exp. 22, p. 40)
94. Gay Lussac's Law (exp. 15, p. 27)
95. Reactions Between Oxides and Water (exp. 25, p. 47)

DEMONSTRATIONS

Alyea, Hubert N. and Dutton, Frederic B. Tested Demonstrations in General Chemistry. Easton, Penn.: Division of Chemical Education of the American Chemical Society, 1966.

1. Types of Solutions (5-8 through 5-21, pp. 13,14)
2. Colligative Evidences (6-11 and 6-12, p. 16)
3. Apparent Degree of Ionization (6-13, p. 16)
4. Deliquescence (10-3, p. 23)
5. Colloids (23-1 through 23-26, pp. 49,50 and 23-1s and 23-5s, p. 136)
6. Models (24-5 through 24-9, p. 51, also 24-74s through 24-85s, pp. 121,122)
7. States of Matter: Solutions (5-2s through 5-91s, pp. 128, 129)
8. Types of Bonds (9-27s and 9-28s, p. 132)
9. Graham's Law of Diffusion (p. 188)
10. Effect of Temperature on Solubility (p. 189)
11. The Solubility of Ammonia (p. 174)
12. Diffusion of Gases (p. 160)
13. Dalton's Law of Partial Pressure (p. 156)
14. Conductivity Test Set (p. 148)
15. Vapor Pressure and Raoult's Law 9p. 145)
16. Hydrogen Bonding in Liquids (p. 143)
17. Detection of Water of Crystallization (p. 199)

PROJECTS

1. Devise an apparatus for the determination of molecular weights or masses of various types of materials.

2. Grow crystals. Check factors and how they affect growth and perfection of crystal. Must devise a method to insure perfection.

3. Use your knowledge of standard solutions and molar ratios to determine quantitatively the chemical content of a variety of materials such as:

   chlorine in canal water
   iron content of well water in various areas
   pH of a variety of brands of vinegar
   specific metal in an ore or alloy
   sugar in a variety of foods grown under different conditions.

4. Determine the percent of ionization of a compound in water. Check to see if and how the degree of ionization of the electrolyte varies with the concentration of the solution.

5. Extract and separate oils from any common source such as citrus peels.

REPORTS

1. Describe in detail the contributions to our modern day model of the atom made by the scientists mentioned in the outline. The repetition of some experiments is possible.

2. Relate the properties of a few selected chemicals to the type of bonding present.

3. Imagine a new element of a specific atomic number and use your knowledge of the trends on the periodic table to predict properties. Explain each prediction and its relationship to structure.

4. Describe the relationship of shape of a molecule to the properties of a substance. Explain each.

5. Describe, possibly by drawings, the different crystalline shapes and explain the factors which determine the shape and stability of a crystalline substance.

REPORTS (Continued)

6. Apply the gas laws to a practical situation such as scuba diving.

7. Describe a variety of methods used to separate mixtures of chemicals. Explain the scientific concept used in each case.

8. List the properties of a solution and explain how and why specific properties vary with the temperature and concentration.

9. Describe the formation of complex ions and explain the method used to predict their formation.

SPEAKERS AND FIELD TRIPS

1. American Society of Metals
   Dr. H. A. B. Wiseman
   University of Miami

2. City of Miami Water Plants
   Director of Department of Water and Sewers
   665-7471

3. Dade County Air and Water Pollution Control
   864 N. W. 23rd Street
   377-5891

4. Each Coast District Dental Society
   2 S. E. 13th Street
   373-2388

5. American Society of Medical Technologists
   Mrs. Anna Rundell
   2213 Red Road
   Coral Gables, Florida

6. Chemistry Department of
   University of Miami

7. Chemistry Department of
   Florida International University

RELATED PROBLEMS

1. Calculate the molecular weight of a gas if 5.20 grams at 78°C and a pressure of 780 mm occupy a volume of 1140 ml.

2. A gas of unknown composition diffuses through a diffusion apparatus at a rate of 15 ml/sec. Oxygen diffuses at a rate of 10 ml/sec through the same apparatus at the same temperature and pressure. Calculate the density of the unknown gas, and assuming it is a pure substance, calculate the molecular weight.

3. In a basal metabolism measurement timed at exactly 6 minutes, a patient exhaled 52.5 liters of air, measured over water at 20°C. The vapor pressure of water at 20°C is 17.5 mm. The barometric pressure was 760 mm. The exhaled air analyzed 16.75 volume % oxygen. The inhaled air contained 20.32 volume % oxygen. Neglecting any solubility of the gases in water and any differences in the total volume of inhaled and exhaled air, calculate the rate of oxygen comsumption by the patient in ml (STP) per minute.

4. A carbohydrate on analysis gave the following percentage composition: C = 40.00%, H = 6.71%, O = 53.29%. Its molecular weight is approximately 180. Determine the molecular formula of the carbohydrate.

5. A drop of water (0.050 cc) at 54°C is injected into a 1.00 liter box that was completely evacuated. If the temperature of the system is kept at 54°C, how much liquid water will be left when equilibrium is established? The density of liquid water at 54° is 0.9862 g/cc. Assume ideal behavior of the gas.

6. What will be the pressure in the box at the end of the experiment described in problem 5.

7. You have collected 38.9 cc of oxygen gas by ethyl alcohol displacement at 19°C. The temperature of the gas is 19°C; the barometric pressure is 757 mm of Hg. At 19°C the vapor pressure of ethyl alcohol is 40.0 mm of Hg. How many moles of O_2 have you collected?

8. The measured vapor pressure of ethyl alcohol is 40.0 mm of Hg at 19.0°C and 100 mm of Hg at 34.9°C. Using the Clausium-Clapeyron equation, figure out how much heat would be required to evaporate one mole of ethyl alcohol in the temperature range of 19.0°C to 34.9°C.

9. A mixture of 8 grams of oxygen, 10 grams of hydrogen, and 7 grams of nitrogen gases have a total pressure of 650 mm of Hg at 27°C. When the oxygen is removed the pressure drops to 550 mm of Hg. What is the partial pressure, volume, and mole fraction of each gas?

RELATED PROBLEMS (Continued)

10. What quantity of heat is required to convert 10.00 grams of ice at 0°C to steam at 100°C? How much heat is evolved in the conversion of 15.00 grams of steam at 100°C to ice at 0°C?

11. Calculate the vapor pressure of water at 120°C, assuming the $\triangle$ Hv for water is 9700 cal/mole.

12. $2\ KMnO_4 + 16\ HCl \rightarrow 2\ KCl + 2\ MnCl_2 = 5\ Cl_2 + 8\ H_2O$

    a. What weight of chlorine is obtained by the reaction of 52.68 grams of $KMnO_4$?

    b. What volume of chlorine gas would be produced by the reaction of 52.68 grams of $KMnO_4$ if the gas were measured at 25°C and 750 mm of Hg (Torr) pressure?

    c. What volume of 15 N HCl would be needed to react with 52.68 grams of $KMnO_4$?

    d. What is the equivalent weight of $KMnO_4$ in the equation above?

    e. What volume of 0.10 N HCl solution would be needed to react with 50.00 ml of 0.052 N $KMnO_4$ solution?

13. Using the chemicals listed below, determine the weight needed to prepare the following: 250 ml of 0.10 Molar solution, a 0.10 molal solution using 100 g of water, 100 grams of 5% solution, and 250 ml of 0.10 normal solution.

    HCl, H_2SO_4, $NaOH$, $Ca(OH)_2$, $NaCl$, $MgCl_2$, Fe^{+3}, NO_3^-, Zn, Na, $Cu(NO_3)_2 \cdot 6\ H_2O$

14. Concentrated sulfuric acid has an assay of 95.7% and a specific gravity of 1.84. What volume of the solution will be needed to prepare each of the following solutions?

    a. 250 ml of 0.10 normal
    b. approximately 100 ml of .05 molal
    c. 100 ml of 0.05 molar.

15. $C_3H_8\ (g) + 5\ O_2\ (g) \rightarrow 3\ CO_2\ (g) + 4\ H_2O\ (g)$

    If 100 liters of propane gas measured at 740 mm and 20°C is burned, what volume of CO_2 at 760 mm and 30°C will be produced.

RELATED PROBLEMS (Continued)

16. A sample of oxygen is passed through a mass spectroscope. If the mixture contains all three isotopes of oxygen (mass # of 16, 17, and 18), what will the photographic plate look like for only +1 and +2 ions?

17. A flask contains 5.0 grams of hydrogen and an unknown weight of neon gas. The total pressure is 760 mm. When the hydrogen is removed the pressure drops to 550 mm. The temperature is constant at 27°C. What is the volume of each gas, weight of the neon, and the mole fraction of each gas?

18. A student used the victor Meyer apparatus to determine the molecular weight of a volatile liquid. The data collected is as follows:

weight of empty vial	20.963 grams
weight of filled vial	21.895 grams
volume of gas displaced over mercury	18.96 ml
atmosphere pressure	751 mm of Hg (Torr)
temperature of gas	50.81°C

What is the molecular weight of the chemical?

19. Using the Dumas Method, the following data was collected for a second chemical:

weight of the bulb	173.901 grams
volume of the bulb	154.6 ml
weight of the bulb filled with vapor	175.730 grams
temperature of the vapor	70.03°C
atmospheric pressure	758 mm of Hg (Torr)

What is the molecular weight of the chemical?

20. Suppose you mix equal volumes of 4.55 molal HNO_3 (density 1.1294 g/ml) and 455 molar HNO_3 (density 1.1469 g/ml). What is the molality of the final solution?

21. The freezing point of a solution of 287 grams of water and 4.68 gram of substance X is -0.153°C. What is the apparent weight of chemical X? What would the boiling point of the solution be?

FILMS AVAILABLE FROM DADE COUNTY AUDIOVISUAL CENTER

1. Behavior of Gases
   I-10717, 15', B/W

2. Colloidal State
   I-10933, 16', C

3. Colloids
   I-01958, 11', B/W

4. Crystals and Their Structure
   I-10824, 22', B/W

5. Crystals
   I-30342, 25', B/W

6. Definite and Multiple Proportions
   I-30327, 21', B/W

7. Demonstrating the Gas Laws
   I-10740, 21', C

8. Electromagnetic Cathode Ray Tube: Theory of Operation
   I-31317, 20', B/W

9. Gas Pressure and Molecular Collisions
   I-10849, 21', B/W

10. The Gas Laws
    I-01831, 10', B/W

11. Mass of the Electron (PSSC)
    I-10763, 18', B/W

12. Millikan Experiment (PSSC)
    I-30314, 30', B/W

13. Molecular Motion
    I-10874, 63', C

14. Molecular Spectroscopy
    I-10869, 22', C

15. Properties of Solutions
    I-30345, 28', B/W

16. Properties of Water
    I-01965, 10', B/W

FILMS AVAILABLE FROM DADE COUNTY AUDIOVISUAL CENTER (Continued)

17. Rutherford Atom (PSSC)
1-40022, 25', B/W

18. Shapes and Polarities of Molecules
1-10895, 18', C

FILM LOOPS

Ealing Film-Loops, 2225 Massachusetts Avenue, Cambridge, Massachusetts 02140

1. Boiling Point and Pressure
80-3403

2. Boyle's Law
80-3387

3. Bragg Reflection of Waves
80-2363

4. Bubble Model of a Crystal: Deformation and Dislocation
84-0124

5. Bubble Model of a Crystal: Structure and Boundaries
84-0116

6. Critical Temperature
80-0124

7. Diffusion
80-2959

8. Finding Absolute Zero
80-3395

9. Gas Diffusion Rates
80-3379

10. Mass of an Atom
80-3353

11. Paramagnetism of Liquid Oxygen
80-2041

12. Properties of Gases
80-2967

FILM LOOPS (Continued)

13. Rutherford Scattering
80-3965

14. Thermal Expansion of Gases
80-3312

15. Thomson Model of the Atom
80-3957

FILM STRIPS

Encyclopedia Britannica Films

1. Determination of a Formula

2. Molar Volume of a Gas

3. Experiments with Atomic Particles

4. Ionization

5. Size of Molecules

(There is a series of filmstrips from Encyclopedia Britannica Films which depict experiments and leave the explanation to the student. Catalogs should be available in your school.)

McGraw Hill Book Company, Text Film Department, 330 W. 42nd Street, New York, New York

6. Kinetic Molecular Theory

7. Chemical Bond

8. Ionization

SUGGESTED DISCUSSION QUESTIONS

1. Under what conditions do gases deviate markedly from the gas laws and how can you account for the deviation?

2. Why can't the formula weight of NaCl be easily determined by the freezing point method?

3. Explain:

   a. In a mixture of Gases A, B, and C, all gases have the same volume.

   b. The volume of the solid solute can not be ignored in preparing a molar or a normal solution. Their volumes are not additive. The variation of the sum from the actual volume varies with the chemical used.

   c. One liter of gas A and one liter of gas B are mixed and the volume remains one liter with constant temperature and pressure maintained.

   d. Air which is forced through a small opening is cool.

4. What relationship exists between vapor pressure of a liquid and the temperature?

5. Which bond is more polar N-F or N-H? Which molecule is more polar NF_3 or NH_3? Repeat for Si-F and S-Cl and SiF_4 and SCl_4.

6. Why would Mg be expected to melt at a higher temperature than Na?

7. The conductance of semiconductors may vary markedly with the temperature. Explain.

8. The chemistry of Li and Be compounds varies markedly from trends in their families. Explain.

9. What causes the boiling point and freezing point of solutions to be different from those of the pure solvent? (Raoult's Law)

10. List the trends in the periodic table (both chemical and physical) and explain each using the atomic structure as a basis.

11. What is a chemical bond?

12. Why are some crystalline substances not stable under normal conditions?

SUGGESTED DISCUSSION QUESTIONS (Continued)

13. What types of facts can be explained using Thomson's and Bohr's models of the atom?

14. What basic factors determine the type of solid a molecule or atom will form?

15. What factors determine the structure of a crystalline substance?

16. What factors determine the type of bond to be formed between two atoms?

17. Why do some atoms hybridize and others do not?

18. Why do we bother to use all the different methods to express concentration of solutions?

19. Why does a carbonated beverage foam when placed over ice cream?

20. If you wish to separate volatile substances, what method would you use? If one component decomposed when heated to the boiling point, what method would you use?

21. Could you use tons and pounds with an equation to show relationships of weights used and produced? (ton and pound formula weights)

ACTIVITIES

1. Make models of (1) crystalline shapes and (2) molecules. Use them to predict polarity and other properties and to show isomerization, etc.

2. Make charts and transpariencies to show trends on the periodic table. Students could be asked to teach a lesson.

3. Students could demonstrate properties of a solution, various gas laws, etc.

4. Display a collection of common colloids.

5. Attempt to repeat historical experiments indicated in the course outline.

6. Use a spectroscope to view various prepared spectrum tubes and flames.

7. Watch crystals grow under a microprojector or stereomicroscope.

8. Make models of orbital shapes and use them to show bonding and the determination of molecular shapes, etc.

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MASTER SHEET--ATOMS, MOLECULES, AND KINETIC THEORY

Objectives	Texts	References	Experiments	Films	Film Loops	Film Strips	Questions	Reports	Projects	Problems	Demonstrations
1	#1. pp. 77-102 #2. pp. 352-393	#1. pp. 536-554 #4. pp. 190-257 #6. pp. 23-48 #7. pp. 562-622 #9. pp. 131-133, 140-151 #8. pp. 36,37 #10. pp. 21-47 #11. pp. 244,245, 254-267 #14. pp. 1-32, 80-116 #15. pp. 42-75 #17. pp. 33-65 #19. pp. 411-460	11,17,32,67	8,11, 12, 14,17	10, 13,15	3	13				
2	#1. pp. 77-102 #2. pp. 352-393	#1. pp. 536-554 #4. pp. 190-257 #6. pp. 23-48 #7. pp. 528-622 #9. pp. 121-151 #10. pp. 21-47 #11. pp. 244,245, 254-267 #14. pp. 1-32, 80-116, #15. pp. 1-16,42-75 #17. pp. 33-65 #19. pp. 411-460	55,82	11, 12,17	13,15	3		1			
3	#1. pp. 96-102 #2. pp. 373-375	#1. p. 553 #9. p. 148 #14. pp. 27,29 #15. pp. 57-62 #18. pp. 7-18 #19. pp. 458,459									
4	#1. pp. 42-44 #2. pp. 18-22	#1. pp. 610-612 #9. p. 411 #11. pp. 242-243 #15. pp. 38-39 #17. p. 38 #19. pp. 436-440									
5	#1. pp. 105-111 #2. pp. 451-471	#1. pp. 554-560 #2. pp. 1-42 #4. pp. 246-255 #8. pp. 151-165 #11. pp. 266,267 #14. pp. 34,35 #17. pp. 58,59 #18. pp. 19-25									
6	#1. pp. 11-120 #2. pp. 451-471	#4. pp. 176-183 #7. pp. 424-430 #8. pp. 158-165 #11. pp.267-272 #14. pp.33-60 #17. pp. 66-73 #18. pp. 28-66	4,41,42,73,84				6,7,8,10 14,16,17	3			

MASTER SHEET--ATOMS, MOLECULES, AND KINETIC THEORY (Continued)

Objectives	Texts	References	Experiments	Films	Film Loops	Film Strips	Questions	Reports	Projects	Problems	Demonstrations
7	#1. pp. 121-198 #2. pp. 397-448	#2. pp. 79-120 #4. pp. 258-287 #8. pp. 167-191, 312-352 #10. pp. 3-20,156 #11. pp. 274-319 #12. pp. 31-107 #17. pp. 77-100, 160-179 #14. pp. 61-80, 117-294 #18. pp. 67-115	2,8,13,15,22,40, 53,54,60,64,75	4,5, 16,18	3-5, 11	5,7	5,7,8,12, 15	2,4,5,9			6,8,16
8	#1. pp. 33-54 #2. pp. 37-48	#1. pp. 4-8 #5. pp. 12-22 #6. pp. 146-149 #7. p. 434 #8. pp. 55-64 #9. p. 44 #11. pp. 49-56 #13. pp. 13-20 #16. pp. 226-238 #17. pp. 127-139 #19. p. 188	1,27,28,51,61, 62,52,76,94	1,7, 9,10, 13	2,6, 8,12, 14	6	1,3			5,6,7	13
9	#1. pp. 33-54 #2. pp. 37-48	#5. pp. 12-24 #6. pp. 146-149 #8. pp. 55-65 #11. pp. 49-56 #13. p. 19 #16. pp. 226-241 #17. pp. 137-139	1,27,28,52,61, 62,51,76,94	1,7, 9,10, 13	2,6, 8,12, 14	6	1,3			7,9,17	13
10	#1. pp. 49-53 #2. pp. 46,49	#1. pp. 9-11 #4. pp. 86,87 #5. pp. 22-27 #6. p. 150 #8. p. 65 #9. p. 69 #13. pp. 21-25 #16. pp. 241-243 #17. pp. 141-144 #19. p. 187	3,6,7,19,21, 20,26,30,34, 44,45,56,65, 66,71,79,90, 80,81,83,93	1,7, 10	7,9	1,2			1	1,2,4. 18,19	9,12,17
11	#1. pp. 264-269 #2. pp. 136-139	#1. pp. 184,212-226 #3. pp. 101-150 #5. pp. 92-98 #6. p. 191 #13. pp. 71-77 #16. pp. 340-345 #17. pp. 197-199	85,86		1		2		4		2,3,15
12	#1. pp. 256-258 #2. pp. 133-135	#1. pp. 182-183 #5. pp. 68-70 #6. pp. 186-190 #8. p. 80 #11. p. 72 #13. pp. 78-92 #16. pp. 319-335, 210-225 #17. pp. 197-199	58				18		3	13,14	

MASTER SHEET—ATOMS, MOLECULES, AND KINETIC THEORY (Continued)

Objectives	Texts	References	Experiments	Films	Film Loops	Film Strips	Questions	Reports	Projects	Problems	Demonstrations
13	#1. pp. 277-281 #2. pp. 116-132	#1. pp. 133-207 #5. pp. 70-82 #6. pp. 102-114, 180-185 #8. pp. 312-352 #10. pp. 224,203, 49-51 #11. pp. 72,300, 317 #17. pp. 206-211	5,9,14,16,23,24, 25,29,31,38,43,49, 50,57,58,63,68,69, 70,72,77,89,91,92	2,3, 15		4,5,8	4,9,19,20	7,8,9	2,4,5		1,4,5,7, 10,14
14	#1. pp. 69-74 #2. pp. 25-34	#4. pp. 96-111 #6. pp. 170-178 #8. pp. 48-50 #11. pp. 224-231 #13. pp. 40-53 #16. pp. 199-209 #17. pp. 100-127	12,18,33,35,36,37, 46,47,48,59,74,78, 87,88,95				21		3	12,15	